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BOOK OF ABSTRACTS

The rivers in our tears: chemistry, literature and conception of reality and science in the short story “Best is the water” by Primo Levi

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Even if it fulfils other purposes, literature can be a means for scientists and non-scientists to express their conceptions of world and science, such as the poet Herman Goeter and his scientific and political (communist) poem analyzed by Zwart (2021). Inspired by this analysis, we attempted to identify the conception of reality and science in a science-fiction short story by Primo Levi (1919-1987). Our main references were: 1) historical and dialectical materialism, with the concept of reality stratified into spheres and a critique of neopositivist science (Lukács, 1984); 2) critical realism, with the concept of reality stratified into domains and a critique of epistemic fallacy (Bhaskar, 2013); 3) active realism, which recommends contact with reality from different angles, rejecting the idea of exclusive truth (Chang, 2012); 4) the conception of the laboratory space as an environment that uses typical and idiosyncratic substances (Bensaude-Vincent and Simon, 2012). Primo Levi was an Italian chemist and writer who was a Jewish prisoner of the Nazis and became known for his literature of testimony. Levi also wrote science fiction short stories, such as those collected in *Flaw of form* (1971), whose title was inspired by his perception of structural defects in society that affect social life and the moral structure, such as the dehumanization caused by the irrational use of science and technology (Ross, 2007).

In the short story “Best is the water”, we follow Boero, a technical chemist who, while carrying out his routine work of measuring the viscosity of distilled water, notices a change in the value. Observing the river Sangone, he notices the change in the water due to its mobility and rumble and takes a sample. “The water was grotesque: 1,300 centipoise at 20°C, 30 percent higher than normal” (Levi, 2015). Levi recounts the drastic consequences that more viscous water has on nature and society, in which we identify the interrelationship between the spheres of reality (Lukács, 1984). The change in viscosity, a property of water (the inorganic sphere), affects vegetation and the human organism (the organic sphere) and impacts labor and the functioning of life in society, making it impossible to grow crops or even enjoy the relief provided by crying (the social sphere). In Boero's perception of the river, outside the laboratory, Levi may have been warning of the distancing from concrete reality that chemistry operates by producing prototypes such as distilled water (Bensaude-Vincent and Simon, 2012) and reducing reality to the domain of the empirical (Bhaskar, 2013). Isolated with their prototypes and tabulated values, chemists tend to absolutize and crystallize knowledge in favor of pure technique. “Now, it should be said that Landolt's tables are sacred: they are the Truth” (Levi, 2015). The fiction of monstrous water strains these values and shows that there is no absolute truth, because a portion of water is not just a cluster of H₂O molecules (Chang, 2012), and matter is in motion, so there may always be unidentified mechanisms about the nature of water and its interaction/reactivity with other substances, especially if we consider chemistry as a generator of new artificial interactions in nature. “The anomaly rapidly expanded in the course of the summer, by a mechanism that defied every attempt at explanation [...]” (Levi, 2015). In the short story, we identified that Levi criticizes the technical work of a chemist and expresses a conception of reality that is stratified and in movement, confronting neopositivist science.

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The widespread confusion in the philosophy of chemistry community regarding the Born-Oppenheimer approximation

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The presentation will set out to clarify a number of confusions that exist in connection with the Born-Oppenheimer approximation (BOA). It is generally claimed that chemistry cannot be reduced to quantum mechanics because of the nature of this commonly used approximation in quantum chemistry, that is popularly believed to require a ‘clamping’ of the nuclei. It is also claimed that the notion of molecular structure, which is so central to chemistry, cannot be recovered from the quantum mechanical description of molecules and that it must be imposed by hand through the BOA. Such an alleged failure of reduction is then taken to open the door to concepts such as emergence and downward causation (Hendry, 2010; Scerri, 2023).

Another mistaken view is that chemists have no choice but to use the BOA (Cartwright, 2022; Chang, 2015; Lombardi, 2023), whereas there is an entire sub-discipline which involves non-Born Oppenheimer calculations, and which regularly and successfully calculates many chemical and biochemical properties of molecules (Agostini, Curchod, 2022). Yet another misconception, according to the present author, is the view that the application of the BOA represents a violation of the Heisenberg Uncertainty Principle (Cartwright, 2022; Chang, 2015; Lombardi, 2023).

Many of the claims made in the philosophy of chemistry community are based on the highly technical papers of authors such as Sutcliffe and Wooley, many of which date from about 50 years ago. While these authors remained skeptical of the possibility of recovering molecular structure from quantum mechanics, others maintained that it would eventually be possible to do so (Löwdin, 1989).

As a matter of fact, significant progress has now been made in this direction. For example, whereas one frequently reads that the full, or Coulombic Hamiltonian, for a molecule precludes the existence of molecular dipoles, some recent calculation which goes beyond the BOA have succeeded in calculating the *exact value* of dipole moment of the LiH molecule (Cafiero, 2004).*

Even more significantly perhaps, a very recent article from a group in Norway has succeeded in recovering the structure of the D_3^+ molecule in a completely ab initio manner without applying the BOA, but through the use of a Monte Carlo approach (Lang et al., 2024).

*Calculated value 2.3140, Experimentally measured value, 2.314 ± 0.001 .

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Multiple realizability in quantum chemistry: valence bond and frontier molecular orbital

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Abstract: This paper will explore chemical classification and acidity by first examining the theoretical foundations of the major acidity models, followed by a detailed discussion on the development of quantum chemistry and its impact on our understanding of chemical bonding and reactivity. The comparison between valence bond and molecular orbital theories will be highlighted, showing their conceptual and practical equivalence in explaining acidity. Ultimately, the goal is to assess whether a unified theory of acids is achievable. Through this exploration, the implications for chemical classification and the defense of a microessentialist view of natural kinds for acids will be critically analyzed. The recent interest in the philosophical dimensions of acidity is driven by two main factors. Firstly, there has been a significant focus on the precise measurement of acidity, which has led to detailed examinations and debates among chemists and philosophers alike (Chang 2012, Ruthenberg and Chang 2017, Scerri 2022). Secondly, there is a burgeoning discourse on chemical classification and the quest for a unified theory of acidity (Tantillo and Seeman 2023, Thyssen 2023). This paper primarily focuses on the latter issue, scrutinizing whether the diverse models of acidity can be integrated into a cohesive theoretical framework. The implications of this work for the classification of chemical substances and the broader understanding of natural kinds in chemistry are also considered.

This paper will explore these topics by first examining the historical and theoretical foundations of the major acidity models (Section 2), followed by a detailed discussion on the development of quantum chemistry (Section 3) and its impact on our understanding of chemical bonding and reactivity. The comparison between valence bond and molecular orbital theories will be highlighted, showing their conceptual and practical equivalence in explaining acidity (Section 4). Ultimately, the goal is to assess whether a unified theory of acids is achievable or, by contrast, if the different models offer distinct valuable insights that collectively enhance our understanding of acids in chemistry (Section 5). Through this exploration, the implications for chemical classification and the defense of a microessentialist view of natural kinds for acids and multiple realizability (Section 6) will be critically analyzed.

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CLASSICAL CHEMISTRY PUT IN PARALLEL WITH THERMODYNAMICS. ITS FOUR WAYS OF REASONING AND ITS SPECIFIC GEOMETRY

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Classical Chemistry has the same fundamental choices of Thermodynamics: 1) a mathematics rejecting actual infinity, rather assuming potential infinity only (no more than resp. rational numbers; exponential numbers); 2) a theoretical organization rejecting the deductive one for first of all trying to resolve a fundamental problem (resp.: how many and what are the elements of matter; the efficiency in heat/work conversions). Moreover, both theories became true scientific theories although rejecting Euclidean geometry and a temporal variable for simulating (like in Newtonian mechanics) the dynamics of the studied reality. Both were successful to solve their specific problems by systematically reasoning without referring to causes, but to impossibilities (resp.: that of *Hyle*; that of perpetual motion) and by making use of doubly negated sentences of non-classical logic (resp. on periodicity of elements' characteristics; on a cycle of transformations).

However classical Chemistry presents two important differences from Thermodynamics. In history of science Mendeleev's building his Table was an exceptional event because he reported his ways of reasoning on the various elements. A detailed examination of his description of how he reasoned shows that he simultaneously made use of all the possible ways of reasoning (= WoRs): induction, deduction, abduction and limitation¹ (These WoRs have been abstracted from various fields of investigation: Charles Peirce's philosophy of reasoning, physical theories and Computer science²); no other scientist building a theory did the same.

One more difference is its odd relationship with geometry: although the latter is lacking as a foundation of the theory, the result of the theory, i.e. Mendeleev's table, enjoys a great variety of graphic representations³. Dennis Rouvray reduced them to four types;⁴ which *grosso modo* correspond to the four kinds of geometries recognised by Henri Poincaré as the basic ones (Hyperbolic, Minkowskian, Elliptic and Euclidean)⁵. Arguments based on WoRs are offered for connecting classical Chemistry to those graphic representations of Mendeleev's table which Vasiliei Shemishin classed under the type “Hyperboloid”⁶. Each of them represents both matter and anti-matter without any neutral element. When projected on a plane these representations are all spirals, which according to Evgeny Imyanitov represent the fundamental geometrical representations of the table.⁷ All that allows conjecturing that the entire classical chemistry may be founded on hyperbolic geometry.

¹ A. Drago (2016), “Il chimico-filosofo C.S. Peirce sulla tabella di Mendeleieff e sui tipi di inferenza per costruirla”, in M. Taddia (ed.) *Atti del XVI Conv. Naz. Storia e Fondamenti della Chimica*, Atti Acc. Naz. Scienze dei XL, ser. V, vol. 39, pt. II, Tomo II, pp. 253-264.

² Drago A. (2019), “Defining a general structure of four inferential processes by means of the two basic dichotomies of human mind”, in **Nepomuceno Fernández Á., Magnani L., Salguero-Lamillar F.J., Barés-Gómez C., Fontaine M.** (eds.), *Model-Based Reasoning in Science and Technology. Inferential Models for Logic, Language, Cognition and Computation*, Basel: Springer, pp. 298-317.

³ Mazurs E.G. (1974), *Graphic Representations of the Periodic System During One Hundred Years*, Chicago: University of Alabama P.; “Chemogenesis - The INTERNET Database of Periodic Tables“ chemiogenesis online.

⁴ Rouvray D.H. (1996), “The surprising Periodic Table: Ten Remarkable Facts”, *The Chemical Intell.*, **2**, 39- 47, p. 43.

⁵ Poincaré H. (1887), “Sur les Hypothèses Fondamentales de la Géométrie”, in *Oeuvres*, vol. IX (1956), Paris: Gauthier-Villars, pp. 79-91.

⁶ Semishin V.I. (1969), “Principles for the construction and forms of the periodic system”. in *100 Years of the Periodic Law of Elements. X Celebration Mendeleev Congress*, (in Russian). Moscow: Nauka, p. 71.

⁷ Imyanitov N.S. (2016), “Spiral as the fundamental graphic representation of the Periodic Law. Blocks of elements as the autonomic parts of the Periodic System”, *Foundations of Chemistry*, **18**, no. 2, 153-173.

Actuation or Acceleration? – Philosophical aspects of catalysis

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Catalysis, the steering of reaction paths and reaction rates by external components is a fascinating part of the systematic art chemistry – but yet a stepchild of the philosophy of chemistry. The field of catalysis poses questions about the causation of chemical processes and thus about causality in chemistry. In any case catalysis has a substance background whose interpretation began with the causality of contact.

Ironically, Wilhelm Ostwald (1853-1932), the anti-atomist extraordinaire, received his Nobel Prize in 1909 just for his achievements concerning catalysis. Ostwald was interested in a fundamental question which is only apparently trivial: How do chemical processes start, and what is the role of the catalyst therein? He assumes that the cause of a substance change is the chemical potential, that is in thermodynamic terms negative free enthalpy. In his view, a chemical process is already underway albeit immeasurably slowly, when the educts are brought together.

Alwin Mittasch (1869–1953), who studied under Ostwald and received his doctorate under Max Bodenstein, argues in his writings on the philosophy of chemistry for another interpretation. For him the catalytic effect is an occasioning, initiating, or actuating causality. In his writings we find the following claim: “The classification of catalysis within the study of reaction kinetics is a matter of science; its epistemological classification within the whole of nature's causal relationships is a matter of philosophy. (Mittasch 1948, pp. 268–269) Mittasch does not give very good marks to the community of specialized philosophers of his day when it comes to "chemical" or "catalytic" causality. (We still have a very similar situation today...)

The (indirect) dispute between Mittasch, the proponent of the catalytic actuation thesis, and Ostwald, the "thermodynamicist," is not merely one of words. Ostwald rejects the causal influence of the catalyst as a driving force categorically; Mittasch wants to consider both elements, the driving force and the actuating effect, as an integrated whole. Consider a non-chemical example as illustration: a brick lying on the edge of a roof. The potential that "pulls" the brick down can be easily quantified if we multiply mass, height, and acceleration due to gravity. And by equating this potential energy with kinetic energy, we can also predict the speed at which the brick will hit the ground when it falls. Yet the crucial point that Mittasch describes better in the corresponding chemical case is this: We do not know if or when the brick will leave the edge of the roof. In essential ways it is the same situation that we face when bringing about chemical equilibriums. Comprehending potentiality is necessary but not sufficient for a comprehensive description and explanation of the process. The actuating or activating element is an integral part of the description of temporality. Let us return to our example: Whoever accidentally or maliciously kicks the brick and thus sets the process in motion (releases it from its impediment) is part of the interpretation. And to speak here of an actuating causality as Mittasch understands it does not necessarily include the claim of causation. One can conceptually separate the actuation and the reason for a (chemical) process. Intriguingly, Ostwald admits to still not fully understand the nature of catalysis even long after having received Nobel honors.

Whereas the driving forces of chemical processes are dictated by natural laws and therefore only manipulatable within limits, the chemists, by creatively designing the reaction ("kinetic control"), have enormous influence on the reaction rate and the reaction path. Designing the reaction usually involves the skillful handling of kinetic impediments. Temporality in contrast to potentiality is thus not determined. The possibilities of designing the course of the reaction in particular are what makes chemistry a systematic art.

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“Having no counterparts in nature”. Clarifying the notion of ‘(un-)naturalness’ in the critique of chemistry

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Chemistry has always been conceptualized—mostly by its critics, sometimes by its advocates—as a domain opposed to ‘nature’. This thought has a long tradition and can be traced back to its (Christian) roots in early chemical crafts and alchemy. With the continuous and exponential growth of the chemical industry in the last two centuries, as well as the ubiquitous implementation of chemical practices and products across the globe, the opposition of ‘chemical’ versus ‘natural’ has lost none of its momentum and is of considerable importance for contemporary environmental critique. Rachel Carson’s *Silent Spring*, which famously describes organochlorine pesticides as “having no counterparts in nature”, is in many ways emblematic of the debate about the ‘(un-)naturalness’ of synthetic chemicals.

The talk offers a systematic clarification of different notions of ‘nature’ that play a role in public debate about synthetic chemicals in the environment. The talk proceeds in four steps. First, different positions in the debate about ‘chemistry and nature’ are outlined and systematized according to their understanding of the terms ‘natural’ and ‘chemical’. Second, these positions are situated in broader traditions of thought about ‘nature’, namely a scientific-naturalistic versus an Aristotelian approach to ‘nature’. Third, a critique of the respective positions is offered: The ecological blank spaces in the scientific-naturalistic position are pointed out and their practical implications for sustainability discussions are made clear. At the same time, it is outlined how an everyday, binary understanding of ‘natural’ versus ‘artificial’ falls short when discussing synthetic chemicals, especially in the case of nature-identical substances.

In a fourth point, the talk offers a ‘way forward’ by suggesting an ‘ecological turn’ and a ‘practical turn’ to the debate about ‘chemistry and nature’. It is recommended to understand the criteria of ‘naturalness’ and ‘unnaturalness’ according to Jens Soentgen’s ecological definition of ‘nature’ (*Der ökologische Naturbegriff*), which sides with the everyday understanding of ‘nature’ and problematizes chemical burdens on the environment from an ecotoxicological and chemoecological viewpoint. At the same time, a shift of attention is recommended, putting the spotlight of the debate less on individual substances *per se* but more on chemical practices *in situ*, asking not about the ‘(un-)naturalness’ of a substances in isolation but about the relationship between a chemical practice and the ‘natural’ state of the ecosystem it is designated to modify. This offers a middle ground for public debate about ‘chemistry and nature’ since, on the one hand, it takes seriously the original ecopolitical impetus of the environmental movement, while at the same time evading philosophical inconsistencies in cases where a chemical is not easy to situate on the natural–artificial spectrum. The talk, therefore, reconciles different positions in the debate about ‘chemistry and nature’, and reconceptualizes that relationship in a way that is philosophically sound, politically relevant, and faithful to its original ecological concerns.

The Dual (Non)sense of the Chemical Element

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Although the nature of chemical elements has been widely discussed in philosophy of chemistry, our assessment of the literature is that existing publications rarely fruitfully engage with one another. The result appears to be a stalemate: a multitude of, oftentimes competing, definitions of the element have been proposed in the literature and the concept remains the object of many unanswered questions.

A central, recurring theme of this debate is the dual sense of the notion of chemical element. This duality is often traced back to Dmitrii Mendeleev who distinguished the element “as a separate homo-geneous substance” from the element “as a material but invisible part of a compound”. Building on the work of Conal Boyce, we argue that Mendeleev did *not* intend to introduce a dual notion of the concept of element. Instead, Mendeleev had a single notion of element in mind. Friedrich Paneth, however, misinterpreted Mendeleev, and is thus responsible for popularising the dual notion of element as simple versus basic substance. The same duality (or ambiguity, if you will) is still present in the current definition of the chemical element, as established by the International Union for Pure and Applied Chemistry.

We argue that this duality is problematic for a number of reasons. First, it introduces a polysemic notion into the language of chemistry, which is bound to lead to confusion. Second, the duality has been elevated to a pressing question in itself through the use of a myriad of philosophical terms which do not contribute to clarifying the issue. Paneth, for example, was quick in pointing out the ‘metaphysical’ and ‘transcendental’ aspects of his element notion. Most philosophers of chemistry have unquestionably adopted Paneth’s dual notion, and have spilled a lot of ink (too much ink, in our opinion) on how to interpret the distinction and relation between the element as simple substance and basic substance.

In this talk, in contrast, we argue against the dual sense of chemical element: if anything, the attribution of two distinct meanings to the concept of element has only confused matters, rather than leading to new philosophical insights. In order to finally do away with this strange allowance for polysemy and lexical ambiguity, we propose to return to a single definition of the concept of chemical element. As we argue, this represents a return to a view similar to that of Mendeleev, who also adopted a single notion of element. Finally, we propose a way for the debate to constructively move beyond the idea of duality, towards other questions that do make the concept of element an interesting topic worthy of continued philosophical investigation, not only in philosophy of chemistry, but also in general philosophy of science and metaphysics of science.

Development of Ottoman Chemistry at 19. Century

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19. century is an important era in scientific improvement at Ottomans because there are many developments in military and educational institutions. In this study, I examine to the Ottoman scholars who work on chemistry at 19. centuries. Derviş Mehmet Emin Pasha, Kırımlı Aziz, Vasil Naum, Ali Rıza Bey, Antonie Calleja are the pioneers of chemistry at Ottoman Empire. These scholars give many fundamental chemistry books that are crucial in history of chemistry in east. They especially studied on medicinal chemistry or military chemistry. By the way, scientific revolutions can be compared with respect to east and west. There are some scholars before ones such as Ömer Şifai, also there are some scholars after 19. century such as Ömer Şevket Öncel, etc. In this respect, chemistry education is institutionalized with the Republic of Turkey in 20. century.

The mutual interaction of didactics and epistemology helped designing an original teaching sequence on intermolecular bonds

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The intersections between the research fields of chemical education and philosophy of chemistry are still insufficient⁸, despite the undoubted rapprochement occurred in recent decades between the fields of history and philosophy of science and science teaching: “Both the theory of science education and, importantly, science curricula and classroom pedagogy have become more informed by HPS”⁹. Kaya and Erduran¹⁰ remark that “Capturing specific instances of concepts from philosophy of chemistry could help advance our thinking on how best to maximize teacher as well as student understanding of chemistry”.

A specific problem of chemical education is that basic chemistry courses often adopt a repertorial mode of presenting disciplinary concepts, that is insufficiently attentive to the net of relationships between them. As a consequence, students build their own alternative conceptual framework¹¹ and develop misconceptions. Greater awareness of the logical structure of chemistry on the part of teachers is crucial to overcoming this problem and can help students achieve a comprehensive and coherent view of chemistry. We took advantage of epistemic reflection to highlight some conceptual knots related to intermolecular bonds and designed a teaching sequence addressing students’ main difficulties on this topic. Some learning obstacles are¹²: the difficulty to understand the concepts of permanent and instantaneous dipole at the atomic-molecular level; their insufficient connection with the known atomic models; the assimilation of dipolar systems to charged species¹³; the misinterpretation of symbols δ^+/δ^- and the underestimation of the implications of electron mobility within atoms^{4,14}; the static and strongly dualist view of primary and secondary bonds; the lack of systemic view of these interactions. This teaching sequence was administered to three classrooms and proved effective in promoting a better understanding of intermolecular bonds.

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REPRESENTATIONAL PLURALITY IN CHEMISTRY (Virtual presentation)

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The question about the representational plurality in science, the fact that the same object can be represented divergently as it is studied by different scientific disciplines, can be formulated at two levels. On the one hand, there is the *micro* level of the individual. The question here is whether a person can hold alternative representations of a natural phenomenon. On the other hand, there is the *macro* level of the community of experts in each area. In this case, plurality refers to situations where different models or theories about the same phenomenon coexist.

In this work we present an approach to the problem of the representational plurality in chemistry that accounts for both the micro and the macro levels. Our ideas are based on the one hand, on an inferentialist account of scientific representations (Suárez, 2024). On the other, they draw on the notion of disciplinary science identities, as is currently used in the current sociology of science (Hyland, 2012, and references therein; for an educational application see Vincent-Ruz and Schunn, 2018). In a nutshell, drawing on the ideas we presented in a previous work, we consider that each scientific field is characterized by a set of representational competencies that are necessary and jointly sufficient conditions for developing an identity for that discipline. In this view, the problem of representational plurality is thus linked to that of identity plurality, to the question of whether it is possible for a person to simultaneously hold alternative identities if they correspond to divergent representations of the same phenomenon.

As an application of our ideas, we study the representation of molecules in chemistry and in physics in the higher secondary-initial tertiary chemistry education interface. We conclude that molecular orbitals should not be employed at preliminary stages of the teaching of the quantum foundations for chemists.

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The Irreducibility of Chemistry to Everettian Quantum Mechanics (Virtual)

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The question of whether chemical structure is reducible to Everettian Quantum Mechanics (EQM) should be of interest to philosophers of chemistry and philosophers of physics alike. Among the three realist interpretations of quantum mechanics, EQM resolves the measurement problem by claiming that measurements (now interpreted as instances of decoherence) have indeterminate outcomes absolutely speaking, but determinate outcomes relative to emergent worlds (Maudlin, 1995). Philosophers who wish to be sensitive to the practice of quantum chemistry (e.g. Scerri, 2016) should be interested in EQM because Franklin and Seifert (2020) claim that resolving the measurement problem also resolves the reducibility of chemical structure, and EQM is the interpretation which involves no mathematical structure beyond that used by practicing scientists. Philosophers interested in the quantum interpretation debate should be interested in the reducibility of chemistry because chemical structure is precisely the kind of determinate three-dimensional fact which EQM should be able to ground if it is to be empirically coherent (see Allori, 2023). The prospects for reduction of chemical structure are poor if it cannot succeed in EQM; the prospects for EQM as a guide to ontology are poor if it cannot reduce chemical structure.

Unfortunately for proponents of chemical reduction and EQM, there are three serious barriers to the reduction of chemistry to EQM. The first concern is that quantum treatments of chemical structure rely on the Born-Oppenheimer approximation, which holds nuclear locations fixed while minimizing the energy of the electronic configuration (Hendry, 2022), but this approximation is not licensed by EQM. The Born-Oppenheimer approximation relies on nuclei and molecular orbitals being simultaneously present, but in the three-dimensional ontology following from the Everett interpretation these only emerge at different energy scales and are not simultaneously present (Miller, 2023). The second concern is that the emergent worlds of EQM are supposed to be decoherent at the macro-scale (Wilson, 2020), but the recent development of superchemistry suggests that chemical reactions can occur in coherent states (Zhang et al., 2023). The third concern is that emergent worlds are only pragmatic pseudo-processes (Wallace, 2012), but this means EQM trades realist physics for mere instrumentalism about chemistry. Absent a commitment to chemical realism, reduction is an empty promise. The prospects for reduction of chemical structure to EQM are therefore poor.

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Surface Charge Electron Shell Atomic Structure

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The current consensus on the atomic structure was formulated about a hundred years ago. In the enlightenment of the newly developed instrumentations and theories the electronic structure of the atoms is reconsidered [1, 2]. It has been concluded that in order to comply with experiments the electron must go through phase transformation from point to a static surface charge when captured by the nucleus. The surface charge electron shell model of the atoms (Fig. 1) is consistent with all the known features of the atoms and offers a physical explanation for Schrodinger's wave equation.

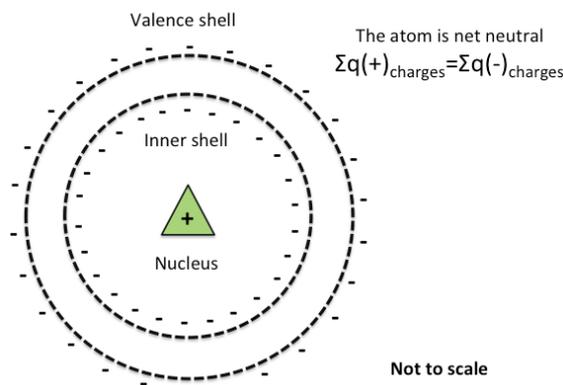


Fig. 1 Schematic figure of an atom is shown. The formed non-rotating electron halo contains all the electrons of the given period of the periodic system of the elements. In every period a new halo starts to form [3]. The nucleus is represented by an equilateral triangle, because the shape of the nucleus resembles a tetrahedron [3, 4].

Energy balance investigations of the model indicated that the stability of the non-rotating surface charge valence electron shell is ensured by the one-dimensional Casimir effect. If this theoretical prediction is correct then the first ionization energies of the elements should correlate linearly to the inverse of atomic diameter. Classical physics approach, electrostatic attraction of the nucleus and the repulsion of the surface charge electron shell, results in an identical relationship. The classical physics approach does not offer adequate explanation for the photoelectric effect and the free electrons inside the metal, indicating that Casimir effect is responsible for the stability of the valence electron shell.

The derived theoretical relationship, between atomic diameter and ionization energy, was tested up to 86 elements of the periodic table. The correlation coefficient is 0.9187. The correlation is stronger for individual periods. The empirical relationship between the ionization energy and atomic radii is well known. Eventhough, this relationship results in the same correlation coefficients, the constant multiplier does not match with the theoretically derived one, contrarily with the atomic diameter relationship. Thus, the first ionization energy is defined by the atomic diameter.

The uncertainties in the reported atomic sizes are relatively high. Therefore, the correlation between theory and experiments should be considered as excellent. The theoretically derived relationship between the first ionization energy and atomic diameter is the consequence of the proposed phase transformation of the electron. Thus the detected strong correlation between theory and experiments adds further support to the proposed atomic structure.

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The Surface Charge Electron Shell Atom Model Consistent with all of the Features of Covalent Bonds

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The empirical concept, shearing the valence electrons results in bond formation, had been deduced from experiments about a century ago. Quantum mechanics interprets the covalent bond formation as the result of the overlapping of the wave functions. The formation of covalent bonds is one of the most fundamental chemical processes, but still lacking adequate physical explanations. There is no consensus, how the shared electrons or the overlapping of the wave function, could bond the atoms together. Analyzing the known features of covalent bonds it is concluded that the static surface charge electron shell atom model, presented at this meeting, can explain and be consistent with all of the features of covalent bonds. The schematic figures, how σ and π bonds formed, are shown on Fig. 1 and 2 respectively.

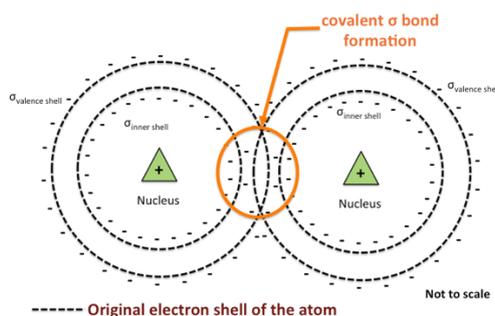


Fig. 1 The overlapping of the trapped surface charge electron shells of the atoms are shown. The attraction of the nuclei and the repulsion of the trapped surface charge valence shells form a σ bond.

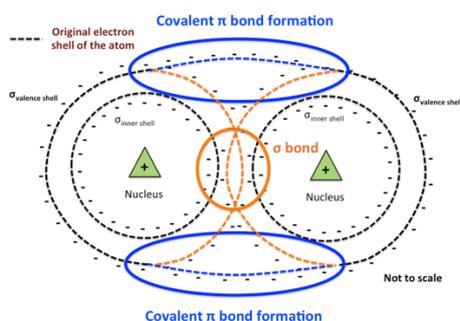


Fig. 2 The schematic of π bond. Following the formation of σ bonds the additional charges in the valence shell can be shared and under the attraction of the nuclei resulting in π bond formation.

The bonds are the result of the electrostatic attractions of the nuclei and the repulsions of the bonded valence electron shells. Using a simplified model, this electrostatic bond formation was tested for Carbon-Carbon bonds. The calculated bond-dissociation energies of the trapped electron shells reproduce the experimental values with one percent error. The proposed model for covalent bonds offers a physical explanation for Gilbert Lewis empirical electron shearing concept.

Emergence, reduction and ontological pluralism in crystalline solids

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During the development of the philosophy of chemistry, various debates have arisen concerning to how the description of matter provided by chemistry relates to those offered by other disciplines. Generally, the debate revolves around molecules (Fortin and Lombardi. 2021), and descriptions based on reduction, emergence, and ontological pluralism have been proposed. However, not everything in the world of chemistry revolves around molecules, and we believe that studying these types of intertheoretical relationships while considering other states of matter can be important. For this reason, in this paper, we will study the topic of intertheoretical relationships in crystalline solids.

In general, crystalline solids are characterized by a periodic structure; thus, studying their chemical properties requires a formalism entirely different from that used for molecules. A crystal is generally described as a network of units (atoms or molecules) that form a lattice held together by some type of force. The heat (and other quantities) exchanged between the crystal and the surrounding bodies is typically described through vibrations in the crystal lattice. However, in practical applications, an alternative description of these phenomena is used, wherein the vibrations can be replaced by a new type of particle, the phonon.

From a theoretical perspective, the phonon has been regarded merely as a mathematical tool that simplifies calculations. However, recently, some arguments have been presented in favor of elevating the ontological status of these entities (Accorinti et al. 2023). On the other hand Franklin and Knox (2018) have proposed elevating the ontological status of phonons, arguing that they can be conceived as an emergent phenomenon. In this work, we present a critical analysis of this proposal and conclude that the requirements for intertheoretical emergence, as proposed therein, are not met. The central point is that both the description of vibrating atoms and that of phonons belong to the quantum domain.

As a counterproposal, we present a formalism that allows for describing quantum systems from different partitions, promoting an ontological pluralism that in this case translates into a vibration-phonon duality. Using this formalism, we argue that the case of phonons can be understood through an ontological duality, but we also show that an emergentist description is possible. Since both are quantum descriptions, it should be considered an intra-theoretical emergence rather than an inter-theoretical one.

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A Third Pillar for the Natural Sciences: World of Chemistry

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Modern science has been structured on the two Galilean pillars: *sensate esperienze* (correct experiences) and *dimostrazioni necessarie* (necessary demonstrations), or in modern terms, experiments and mathematics, since its inception in the 17th century. For example, a century and a half after Galileo, Immanuel Kant reiterated that in every particular doctrine of nature, one can find as much science as there is mathematics within it. The close relationship between science and mathematics made it difficult in the 17th century to include chemistry, reflections on living beings, and medicine within the scientific field. In the following centuries, the chemical-biological-pharmaceutical-medical area was, on the one hand, partially "mathematized" and, on the other, claimed its own "different" scientific nature, centered on the concepts of chemical substance (and molecule / macromolecules in the microscopic world) and on chemical processes. In the recent debate in the philosophy of biology, a new philosophical current, known as the *new mechanical philosophy* (or, for brevity, the *new mechanism*), has highlighted that the explanation of biological processes does not occur with the concept of natural law, as in physics, but with the concept of mechanism: a set of entities that carries out its activity in a particular space/time organization. The paper "Thinking About Mechanisms" by Machamer, Craver, and Darden in 2000 is considered the birth of this new approach. Chemistry has always used the explanation by composition and the concept of mechanism to explain both the properties of materials and their transformations. It is the chemical perspective, that of active entities organized in space and time, which has added the third pillar, not exclusive but essential, in the scientific area which ranges from biology to medicine, via pharmaceuticals. We believe that this pillar transcends this scientific area and can be considered a third pillar of scientificity for the natural sciences.

Neoalchemy in the light of new information technologies

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One of the founders of the modern philosophy of technology, Gilbert Simondon, wrote back in 1958: “Human knows what goes into the machine and what comes out of it, but not what happens in it” [1]. Today, the introduction of neural networks into everyday life, the unpredictable consequences of their further rapid spread indicate that “machinery” begins to live its own autonomous life. Despite the fact that the neural network is designed according to the principle of the human brain functioning, it is not known how the process of its self-learning takes place, because the neural network corrects its own mistakes without human intervention and, as a result, can make independent decisions. These challenges require new tools and approaches to explain what is happening, to revise the positions of classical philosophy and science.

Interactions occurring within a neural network evade rational explanation and usual way of understanding based on cause-and-effect relationships, which is confirmed by the nonlinear and poorly formalized process of its functioning. A correlation with the predominance of randomness is found between the data uploaded to the neural network and the result obtained at the output.

This is one of the reasons to turn to ancient, pre-modern cognitive practices. For example, to rethink the magical picture of the world and to establish homology (structural similarity), an acausal correlation between the work of the neural network and alchemy “based on ideas about the trans-historical parallelism of the development of metaphysical abstractions and postmodern informatical abstractions” [2, p. 91].

In the history of science (even before the rapid development of AI), there are cases of scientists turning to mystical teachings, alchemy and esotericism, for example, in interpreting the provisions of quantum mechanics and explaining various degrees of quantum entanglement [3].

One of the tasks for new digital alchemists in explaining the results of deep neural networks functioning may be the reception of ideas of Renaissance scholarship, which will help to see paradigm shifts in the culture of deep learning, often suppressed by enlightenment-oriented ideology. These are various teachings about non-causal connections – quasi-causations, coincidences, synchronicities, which are traditionally replaced by statistical analogues. In statistical terms, astrology can be attributed to the historically first science of big data, about the establishment of correlations between regular and generally significant processes in the sky and a large array of things on earth. Then alchemy can be attributed to the historically first science of the transformation of matter based on non-causal connections. In alchemy, as well as in astrology, one can find rows in which not the things themselves are correlated but their signs, i.e. the words by which things are designated. In the digital age, neoalchemy operates with “digital matter” (something that can be stored in computer memory), and deep learning of neural networks can (homologously to alchemy) be defined as the transformation of “digital matter” based on non-causal connections.

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The historical evolution of scientific instruments as an inspiration for chemistry teaching: the case of UV-visible spectroscopy

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Museums of Science and Technology, along with historical Collections of scientific instruments and historical finds, possess significant educational potential. The evolution of scientific instruments is intertwined with both technical and conceptual innovations, resulting from cooperative efforts among contemporary scientists.

Drawing from experiences gained in chemistry teachers' training courses [1] and intense research on teaching and learning spectroscopy [2], I aim to highlight the diverse roles of historical instruments and their evolution in enhancing chemistry education.

The case study here reported concerns the teaching of fundamental concepts behind one of the most used and common spectroscopic techniques: UV-visible spectroscopy.

The context of actual ways and methods used to teach this important topic at the frontier of Chemistry and Physics has been deeply analyzed taking into account the Johnstone's triangle model of teaching and learning chemistry [3].

Starting from several critical issues related to the understanding of basic concepts related to the interaction between light and matter, I will present a novel didactic sequence designed and partially experimented with students within a pilot study aimed to introduce Spectroscopy at high school and first introductory courses of physical chemistry. The sequence is inspired by the historical evolution of spectroscopic instruments from the first spectroscopes invented by Gustav Kirchhoff and Robert Bunsen in 1860 to the UV-vis spectrophotometers which became common since the 1960s [2]. The identification of key ideas related to conceptual advancements through the history of spectroscopy will be discussed underlining the advantages of an historical-epistemological approach.

This presentation finally aims to reflect on the potentialities of an historical approach combined with a laboratorial one [1,4], and to discuss the role of historical instruments and related technological improvements to teach several fundamental topics in chemistry.

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Disciplinary status of chemistry by the end of the 18th century in context of the works of I. Kant, K.G. Hagen and I.B. Richter

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The question of the place of chemistry in natural science of the 17th-18th centuries has been controversial during many decades.

The significant role in resolving this issue at the certain time belonged to the philosopher Immanuel Kant (1724-1804), who knew all the ins and outs of the achievements of contemporary science and made an attempt, understanding the strengths of the experimental way of obtaining knowledge, to combine two opposing approaches in theory knowledge - rationalism and empiricism. Because of the "purely empirical principles" of chemistry and the empirical laws that follow from them, Kant called this discipline as a "systematic art." According to Kant, in any natural science there should be exactly as much pure (real) science as it contains mathematics and a priori knowledge.

Karl Gottfried Hagen (1749-1829) soon became Kant's colleague at the University of Königsberg. Revolutionizing the entire teaching of natural science he sets out in his textbooks on apothecary art and experimental chemistry in an accessible form and impeccable style the inductive method of working with Kantian logic and consistency. Kant, his great friend and teacher, called them "masterpieces of logic."

Again, as first noted in the paper, as a result of Hagen's collaboration with Kant in 1789 was the defense of I. B. Richter (1762-1807). He defended an unique dissertation which is one of early examples of essays on mathematical chemistry. In it and subsequent ones Richter outlined in detail his doctrine of stoichiometry, formulated the law of equivalent ratios, which is still one of the main ones for calculating the masses of substances taking part in chemical transformations. Richter emphasized in his work that he consider chemistry as a branch of applied mathematics.

Foregoing collaboration and personal multifaceted cooperation led to the fact that by the end of the 18th century in the light of Kantian scientific theory the disciplinary criteria of chemistry as a "science in the proper sense" were largely legitimized.

I would like to remind that 2024 is marked with two anniversaries: the 300th anniversary of the outstanding philosopher I. Kant and the 275th anniversary of his friend and famous colleague K.G. Hagen. To commemorate these milestones – an important task for the scientific community.

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When is it Worth it – chemicals at industrial scale?

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Chemistry has a bad name, mainly because chemicals in the form of waste have caused economic, human health and ecosystem health problems – some at global scale. There is no one person, or class of people, to blame; the problem is better appreciated as a systemic and complex problem [Vancik], making diagnosis difficult.

The point is not to complain, or blame, but to find a way out of the problem. I propose to outline a method of problem extrication by using the institutional compass [Friend] as a logic of discovery [Cellucci].

Logic that generates hypothetical entities that can be realized as affordances

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Why do we believe in ‘bond’ against an objection raised from quantum mechanical calculations? (Parr and Yang 1994, pp. 218-222; Dewar 1969, pp. 142-143) Since, as we revealed, we can count what becomes actualized as something useful—i.e. the affordance—as real, the reason will be that there is at least a context in which it becomes realized as such. The concept of bond actually makes sense in the practices of organic synthesis. (Ochiai 2023, pp. 141-149 and references cited therein) And yet, why on earth does it always become realized as is expected on such occasions? Is there any logic that make all this possible? These are the questions addressed in this study. Since ‘bond’ is a concept generated through transdiction, the logic intrinsic to this type of reasoning must be responsible, and so it is the focal issue to be investigated. Transdiction is defined as making an inference not only within the bounds of the senses but also across those bounds. (Mandelbaum 1966, p. 61) We conceive of what is happening beyond those bounds and explicate things and events we observe. To be more specific, as we discussed elsewhere, since things are useful—or in other words functional—and the being of beings is known through usefulness they afford us, it is the functional aspects of an object that is placed in the light of cognition. (Ochiai 2023, Buenos Aires) That is, we observe functions of things, from which, through transdiction, we conceive of the functional aspects of molecules and explicate how things work as they do. This is the reason why hypothetical entities such as ‘bond’ always become realized in such a way that we expect them to be. In a word, hypothetical entities are real as a function.

Key words: affordance, transdiction, bond, molecular structure

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Representation of chemical communication systems: the search for parent system

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Recent investigations of communications between macromolecules and corresponding molecular aggregates on the micro scale¹ afford the opportunity for the study of systems by using chemical examples.

In this work such chemical communication systems are represented by using chemical graph theory,² the method that has already applied in the general system studies.³

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The Chemical Revolution Reflected in Evolution of a Textbook – the End of the Phlogiston Era in Central Europe Observed through Six Editions of Horvath's *Elementa Physicae* (1790-1819)

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When L. A. Lavoisier published his textbook *Traité élémentaire de chimie* in 1789, the phlogiston theory was already firmly on the path of total extinction – so much so that in the textbook, Lavoisier no longer refuted it, barely finding it necessary to mention it at all outside an overview of the history of chemistry. While by this date the majority of chemists in the Western Europe have (at least partly) accepted Lavoisier's *Antiphlogistic* view (albeit with few notable, and often vociferous, detractors), the ideas which have been developed over the previous decades in the West have only started filtering through towards the Central and Eastern Europe. This can in part be attributed a smaller number of active chemists (and scientists in general) in these regions, and partly to language barriers. For example, in the eastern part of the Austrian empire, most members of the educated classes were fluent in the main languages of commerce (German and Hungarian) and scholarship (Latin, which has remained the language used in education even at secondary level well into the 19th century), as well as local languages, but very rarely French, and almost never English. For these reasons, the information on new scientific discoveries and new views tended to arrive with considerable delay. In this talk, we shall demonstrate this general principle of the spread of scientific data in the abovementioned region by observing how the chemical subject is treated in a series of editions of a widely used textbook which have been printed over the period when the 'new' chemistry was making its way into the region.

The *Elementa Physicae* (Basics of Physics) by Johannes Baptista Horváth (1732–1799) was a university level textbook on physics (including astronomy, meteorology, and chemistry) which was widely used throughout the eastern part of the Austrian empire comprising modern Hungary, Slovakia, Croatia, and Slovenia, as well as parts of Czechia, Poland, and Romania). It has appeared in print six times, first four editions (1790, 1792, 1794, 1799) during Horváth's own lifetime, and two (1807 and 1819) posthumously, edited by his former assistant Jozsef Szarka (1764–1827). The swift succession of the first four editions was partly due to the great demand for the textbook, but also due to Horváth's desire to keep his textbook up to date with the latest discoveries (he was aware of). The first two editions deal with chemistry entirely in light of the phlogiston theory, while the third edition (1794) was directly prompted by Horváth's acceptance of the antiphlogistic theory and included a greatly altered section on chemistry, with both theories expounded but the antiphlogistic theory clearly preferred. In the 1807 (posthumous) edition, Szarka has entirely abandoned phlogistic theory in explanation of chemistry (explicitly referring to it as obsolete), but has kept the old nomenclature derived from it, making a strange (and possibly unique) hybrid which has remained in use even in the last edition of the textbook in 1819. In the talk we shall observe in more detail how the presentation of chemistry (and chemical theories) changed from one edition to the next, and attempt to reconstruct which discoveries and publications prompted the author to introduce those changes.

Chemical Reactions as Causal Relations

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I consider whether chemical reactions can be understood as causal relations by addressing two questions. First, what are the relata of this putative relation, and second, what is the relation? With respect to the first question, I examine the role of thermodynamic conditions and catalysis in the realisation of chemical reactions. Based on this, I point out that it is not a straightforward matter to establish the relata of this putative relation because classic problems around causation arise. With respect to the second question, I employ Hall's (2004) distinction between causation as production and dependence. I consider which of the two is best supported in light of what we know about chemical reactions from chemistry. In particular, I consider the role of reaction mechanisms and affinity tables and argue that these two features match better with the idea of causation that is formulated by productive accounts. All in all, while a non-Humean understanding of causation may fit better to how reactions are generally construed, what chemical reactions are is far from uncontroversial.

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Varieties of realism and the philosophy of chemistry: Thinking from and with Bensaude-Vincent, Bunge, Chang, Harré, Schummer and Vihalemm

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In recent years, several philosophers have developed new varieties of realism based on chemistry. In so doing, they have provided new arguments and even opened up new avenues of thought. This lecture will analyse and discuss their arguments, their presuppositions and their use of chemistry. Particular attention will be paid to their use of instrumentation, their study of chemical practices, the relational approaches to chemical substances they share and the role they give to modelling work. The contributions to this debate by Bernadette Bensaude-Vincent, Mario Bunge, Hasok Chang, Rom Harré, Joachim Schummer and Rein Vihalemm will be examined. A comparison with Bachelard's earlier work will be proposed and new perspectives will be brought to the fore.

Keywords: Realism. Epistemology. Chemistry. Affordances. Emergence. Practices. Relations. Models. Context-dependence. Pluralism.

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The Response to the Periodic Table in Japan

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How did the Japanese accept the periodic table?

In the first half of the 19th Century Japanese scholars translated chemistry books from Dutch into Japanese. They had to overcome Western thought and to invent new terminology for the new discipline. Udagawa Youan (1798-1846) translated his large book *Seimi Kaiso* from more than twenty four books. Kawamoto Komin (1810-71) followed, included Dalton's atomic rules in his book. The vocabulary they coined for chemistry is partly in use today.

After Meiji Restoration in 1868, Japanese students were dispatched to England to study. Students of Henry Roscoe (1833 – 1915) in Manchester translated his book on chemistry *Roscoe's Science Primers Chemistry in 1873-74*.

First translation of books by Lothar Meyer, Mendeleev and Ian Remsen were published in the 1880s. Textbooks after 1902 mentioned the periodic law.¹

Matsui Naokichi, the first Japanese professor of chemistry in the Department of Chemistry at Tokyo University, mentioned Mendeleev's Periodic Law for the first time in Japan in 1882, in the Journal of the Tokyo Chemical Society. Matsui explained the law as a recent discovery based on Cannizzaro's atomic weights.

In the 1890s the first generation of Japanese professors of chemistry, after returning to Japan from studies abroad, wrote chemistry textbooks for secondary schools and for introductory courses of chemistry in higher education, mentioning Mendeleev's Periodic Law.

Mendeleev's Periodic Table is presented in Takamatsu Toyokichi, *A Textbook of Chemistry* (Tokyo 1891). Takamatsu mentioned the gaps in Mendeleev's table for the missing three atoms and their later discoveries: Scandium, Gallium and Germanium, which contributed to the acceptance of the table.

1. Masanori Kaji, Chemical Classification and the Response to the Periodic Law of the Elements in Japan in the Nineteenth and Early Twentieth Century, in *Early Responses to the Periodic System*, Eds. M. Kaji, H. Kragh, G. Palló, Oxford University Press 2015.

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CONFERENCE PROGRAM

Monday, 15 July			
8:30 - 9:00	Registration		
9:00 - 9:20	Opening of the Conference		
9:20 - 10:00	Michèle Friend	When is it Worth it – chemicals at industrial scale?	
10:00 - 10:30	Hirofumi Ochiai	Logic that generates hypothetical entities that can be realized as affordances	R
10:30 - 11:00	Coffee break		
11:00 - 11:40	Carlos Sérgio Leonardo Júnior	The rivers in our tears: chemistry, literature and conception of reality and science in the short story “Best is the water” by Primo Levi	R
11:40 - 12:10	Sebastian Fortin	Emergence, reduction and ontological pluralism in crystalline solids	R
12:10 - 12:40	Valentina Domenici	The historical evolution of scientific instruments as an inspiration for chemistry teaching: the case of UV-visible spectroscopy	
13:00	Varaždin County Presentation		
	Lunch break		
15:00 - 15 :40	Elena Ghibaudi	The mutual interaction of didactics and epistemology helped designing an original teaching sequence on intermolecular bonds	R
15:40 - 16:10	Antonino Drago	Classical chemistry put in parallel with thermodynamics. Its four ways of reasoning and its specific geometry	R
16:10 - 16:40	Christian Schnurr	“Having no counterparts in nature”. Clarifying the notion of ‘(un-)naturalness’ in the critique of chemistry	
16:40 - 17:10	Sarah Hijmans	The Dual (Non)sense of the Chemical Element	R

Tuesday, 16 July			
9:00 - 9:40	Vladimir Stilinović	The Chemical Revolution Rreflected in Evolution of a Textbook – the End of the Phlogiston Era in Central Europe Observed through Six Editions of Horvath's Elementa Physicae (1790-1819)	
9:40 - 10:10	Yona Siderer	The Response to the Periodic Table in Japan	R
10:10 - 10:40	Elena Baum	Disciplinary status of chemistry by the end of the 18th century in context of the works of I. Kant, K.G. Hagen and I.B. Richter	
10:40 - 11:00	Coffee break		
11:00 - 11:30	İlknur Şahin	Development of Ottoman Chemistry at 19. Century	R
11:30 - 12:00	Pedro Sánchez-Gómez	Representational plurality in chemistry	R
12:00 - 12:30	Hrvoj Vančik	Representation of chemical communication systems: the search for parent system	R
	Lunch break		
15:00 - 15 :40	Eric Scerri	The widespread confusion in the philosophy of chemistry community regarding the Born-Oppenheimer approximation	R
15:40 - 16:10	Giovanni Villani	A Third Pillar for the Natural Sciences: World of Chemistry	
16:10 - 16:40	Natalia Knekht	Neoalchemy in the light of new information technologies	
16:40 - 17 :10	Vanessa A. Seifert	Chemical Reactions as Causal Relations	R
19:00	Conference dinner		

Wednesday, 17 July			
9:00 - 9:40	Klaus Ruthenberg	Actuation or Acceleration? – Philosophical aspects of catalysis	R
9:40 - 10:10	Jozsef Garai	Surface Charge Electron Shell Atomic Structure 1, 2	
10:10 - 10:40	Jean-Pierre Llored	Varieties of realism and the philosophy of chemistry: Thinking from and with Bensaude-Vincent, Bunge, Chang, Harré, Schummer and Vihalemm	R
10:40 - 11:00	Cofee break		
11:00 - 11:30	Juan Camilo Martínez González	Multiple realizability in quantum chemistry: valence bond and frontier molecular orbital	R
11:30 - 12:00	Ryan Miller	The Irreducibility of Chemistry to Everettian Quantum Mechanics	
	Closing remarks		